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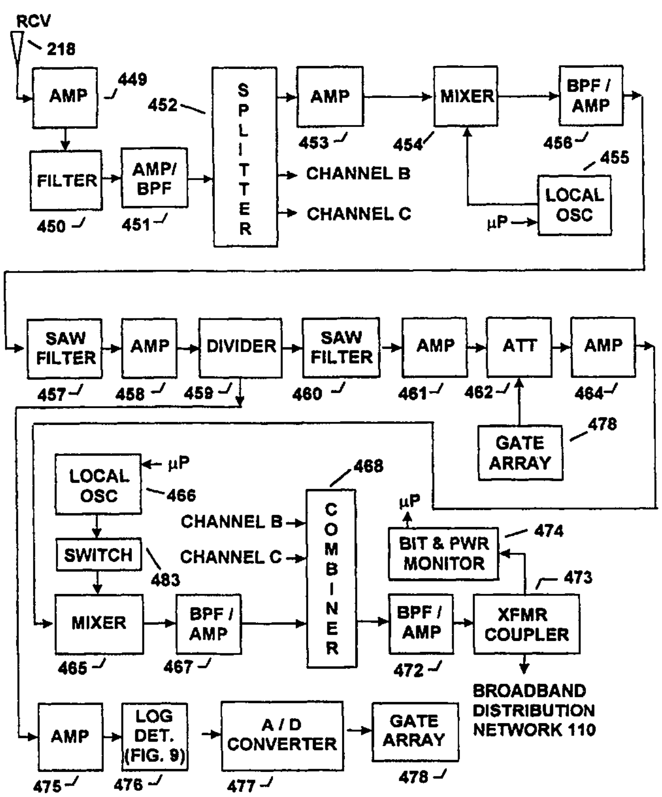
(57) Abstract

An arrangement is disclosed for improving the signal to noise ratio on the reverse path of a GSM wireless communications system that utilizes an existing broadband distribution network to carry communication signals between wireless telephones and remote transceivers to centrally located transceivers and the telephone network. The signal to noise ratio is improved by a time slot muting arrangement in the remote transceivers that senses when there is no communication signal coming from a wireless telephone for a predetermined period and provides squelching in the remote transceiver during any time slot in which a wireless telephone is not operating to thereby reduce white noise applied to the broadband distribution network.



RAD CIRCUIT 419

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GSM TIME SQUELCH

Field of the Invention

The present invention relates to a wireless communications system that incorporates an existing broadband distribution network to carry communication signals between wireless telephones and remote transceivers to centrally located transceivers and the telephone network, and more particularly to a time squelch arrangement that helps minimize noise on the network caused by a plurality of the remote transceivers simultaneously connected to the network.

Background of the Invention

The prior art teaches the use of an existing broadband distribution network, such as a cable television distribution network, to carry telephony signals between an existing telephone system and a large number of remote transceivers positioned to provide overlapping signal coverage in defined cells or sectors. The remote transceivers, called Remote Antenna Drivers (RADs), are used to establish wireless telephony communication links with wireless telephones (also called mobile units herein) operating within an operating area covered by each RAD. Such broadband distribution networks include fiber-optic cable, coaxial cable, radio links and combinations of these.

Between the telephone system and the broadband distribution network is centrally located equipment for carrying the telephony signals between the telephone system and the network. This centrally located equipment typically includes a plurality of Base Transceiver Stations (BTSs) and a plurality of Remote Antenna Signal Processors (RASPs). Each BTS is connected to the telephone system and to the RASPs. Each RASP is connected to a BTS and to the broadband distribution network.

A large number of the above mentioned Remote Antenna Drivers (RADs), are connected to the broadband distribution network and simultaneously communicate with the Remote Antenna Signal Processors (RASPs) via the broadband distribution network using radio frequency carrier signals to carry telephony signals between wireless telephones and the RASPs. This mode of operation is called simulcasting. The RADs transmit radio frequency signals to, and receive radio frequency signals from, wireless telephones operating in their assigned area of coverage in a manner well known in the

art. Telecommunication signals traveling toward a wireless telephone are traveling in, what is called in the art, the "forward direction", and signals originating at a wireless telephone and traveling toward the BTS are traveling in, what is called in the art, the "reverse direction".

In a GSM wireless telephony system, which utilizes time division multiplexing techniques, each wireless telephone has its own periodic time slot in periodic time frames in which it transmits (reverse direction) and receives (forward direction) signals over the broadband distribution network. However, during the time that wireless telephones are not transmitting signals in their assigned time slot in the reverse direction via a RAD and over the network to a RASP and BTS, their reverse signal path is still connected by the RAD to the broadband distribution network in a manner that contributes to the noise level on the reverse direction signal path of the network. With the large number of RADs typically connected to a broadband distribution network in the reverse direction with this type of wireless telephony system the amount of noise can be significant. The non-coherent sum of the noise introduced by the RADs can be expressed by the equation NOISE INCREASE = 10 LOG N, where N is the number of GSM RADs simulcasting over the broadband distribution network toward the RASPs. For example, fifteen RADs will increase the noise in a frequency channel on the broadband distribution network by 12dB. This effectively eliminates at least 75% of the coverage area available from GSM based RADs operating in a non-simulcast mode.

Summary of the Invention

Thus, there is a need in the wireless telephony art for apparatus and a method to improve the signal to noise ratio on a broadband distribution network by reducing the noise introduced by individual system elements connected to the network.

The above described need in the wireless telephony art is satisfied by the present invention. The improvement is made in the Remote Antenna Drivers (RADs) by reducing the noise they each individually contribute onto the broadband distribution network. The result is an improvement in the overall signal-to-noise ratio on the broadband distribution network.

In the well known GSM type wireless telephone system each wireless telephone is assigned its own periodic time slot in which to transmit (reverse direction) and receive

(forward direction) encoded telephony signals. During the time slot in which a wireless telephone is transmitting encoded telephony signals to a RAD and then over the broadband distribution network to the RASPs and BTS, all other wireless telephones operating with the same RAD have their reverse signal path connected via the RAD to the network in a manner that they all contribute to noise on the reverse path of the network. In accordance with the teaching of the present invention, to reduce this noise the reverse signal paths of all RADs are opened toward the broadband distribution network except when a RAD is to transmit signals over the network during their assigned time slot. By having the reverse direction signal path from a RAD connected to the network only when there is a signal from a wireless telephone traveling toward a RASP and BTS, white noise is reduced and the signal to noise ratio on the network is greatly increased. This may be called "time squelch" or "time slot muting". This operation permits reverse path simulcasting GSM RADs to realize a coverage area nearly the same as in non-simulcasting operation.

Description of the Drawing

The invention will be better understood upon reading the following Detailed Description in conjunction with the drawing in which:

Figure 1 is a general block diagram of a wireless telephony system integrated with an exemplary broadband distribution network; and

Figure 2 is a highly simplified block diagram of a Remote Antenna Driver (RAD) used with a wireless telephony system of the type which utilizes a broadband distribution network;

Figure 3 is a detailed block diagram of that portion of a Remote Antenna Driver (RAD) that receives telephony signals via a broadband distribution network from a central transceiver called a Remote Antenna Signal Processor (RASP) and transmits them to wireless telephones operating in a cell area assigned to the RAD;

Figure 4 is a detailed block diagram of that portion of a Remote Antenna Driver (RAD) that receives telephony signals from wireless telephones operating in a cell area assigned to the RAD and transmits them via a broadband distribution network to a Remote Antenna Signal Processor (RASP);

Figure 5 represents the time slots and time frames that a GSM based wireless telephony system operate with;

Figure 6 represents the propagation delays occurring in both directions of a wireless telephony system integrated with an exemplary broadband distribution network:

Figure 7 shows when multiple samples of the received signal are taken in a time slot;

Figure 8 is a block diagram schematic of a burst tone detector; and

Figure 9 is a block diagram schematic of wireless telephone signal level detector.

Detailed Description

In the drawing and following detailed description all circuit elements are assigned three digit reference numbers. The first digit of each reference number indicates the figure of the drawing in which an element is located. The second and third digits of each reference number indicate specific circuit elements. If the same circuit element appears in more than one figure of the drawing, the second and third digits of the reference number for that circuit element remain the same and only the first digit of the reference number changes to indicate the figure of the drawing in which the circuit element is located. Thus, antenna 116 in Figure 1 is the same antenna labeled 216 in Figure 2.

The term "reverse direction " refers to any signals traveling in the direction from RAD 114 toward Telephone System 111, and the term "forward direction " refers to any signals traveling in the direction from Telephone System 111 toward RAD 114. In the Cable Television industry the "forward direction" is referred to as "downstream", and the "reverse direction" is referred to as "upstream". This is mentioned because the wireless telephone system described herein can be utilized with a cable television distribution network.

As used herein the term "telephony signals" includes voice, data, facts and any other type of signals that are sent over a telephone network now or the future.

In Figure 1 is shown a simple block diagram of an exemplary Broadband Distribution Network 110 integrated with elements of a wireless telephone system which include a plurality of remote transceivers known as Remote Antenna Drivers (RAD) 114 a-i. There are different types of Broadband Distribution Networks 110 in use, and such

networks may utilize coaxial cable, fiber optic cable, microwave links, or combinations of these. The Broadband Distribution Network 110 disclosed herein is a conventional hybrid fiber coaxial (HFC) cable to which the plurality of RADs 114 a-i are connected. To avoid detracting from the description of the present invention other well known elements of such a network, such as line amplifiers and transmission equipment feeding signals onto the network, such as cable television signals, are not shown in Figure 1 and are not described in this Detailed Description. Electrical power is distributed along Broadband Distribution Network 110 to power line amplifiers (not shown) of the broadband distribution network. This electrical power source, or alternate power sources, are also used to provide power to RADs 114 a-i.

Telephony signals and control signals to be sent between telephone system 111 and wireless telephones 115 are carried via Broadband Distribution Network 110 using RASP 113 and RADs 114 a-i.

Integrated with Broadband Distribution Network 110 is a wireless telephony system in which the present invention is utilized. One such wireless telephony system is taught in U.S. Patent application 08/695,175, filed Aug 1, 1996, and entitled "Apparatus And Method For Distributing Wireless Communications Signals To Remote Cellular Antennas".

The telephony system disclosed herein includes a Base Telephone Station (BTS) 112 which is connected to a telephone system 111. BTS 112 is also connected to a plurality of Remote Antenna Signal Processors (RASPs) 113 which are the interface to the Broadband Distribution Network 110. Only one BTS 112 and one RASP 113 are shown in Figure 1 for simplicity. In reality, there will be many BTS 112 and RASP 113 circuits to handle wireless telephony traffic in the wireless telephony system. Similarly, only nine RADs 118 a-i are shown in Figure 1, but in reality there are a large number of RADs in a typical wireless telephone system.

As is known in the prior art, including the above cited prior patent application, one or more frequency bands or channels of the Broadband Distribution Network 110 are reserved to carry telephony signals between telephone system 111 and wireless telephones 115. Telephony signals originating from telephone system 111 and directed to a wireless telephone 115 are transmitted by RASP 113, along with control signals, via Broadband Distribution Network 110 to ones of the plurality of RADs 114 a-i which are

connected to network 110. Normally, only the RAD 114i with which a wireless telephone 115 is functioning at one point in time receives the telephony signals and transmits them to wireless telephone 115. Telephony signals originating at wireless telephone 115 are received by the RAD 114i with which telephone 115 is functioning at one point in time. Telephony signals from many wireless telephones 115 are frequency and time multiplexed together by RADs 114 a-i and transmitted along with control signals via Broadband Distribution Network 110 to an associated RASP 113, and thence to Base Telephone Station 112, and finally to telephone system 111.

In addition, in the known GSM wireless telephony system, encoded reverse path telephony signals from wireless telephones 115 are time division multiplexed together and they each transmit and receive their telephony signals within assigned periodic time slots. In addition, there are three channels in each RAD 114, each operating at a different operating frequency. Thus, for example, in a first time slot of a RAD 114 a first-wireless telephone sends a portion of its encoded reverse wireless telephony signals to RASP 113 and receives a portion of its encoded forward telephony signals. In a second time slot of the same RAD a second wireless telephone sends a portion of its encoded reverse telephony signals to RASP 113 and receives a portion of its encoded forward telephony signals, and so on. When the seventh wireless telephone connected to this RAD 114 transmits in its time slot, the process repeats itself. However, when a wireless telephone connected to the RAD is not transmitting in its time slot for a predetermined period of time, the associated RAD circuitry is muted during every occurrence of that time slot in accordance with the teaching of the present invention, and does not contribute to noise on broadband distribution network 110.

In each Base Telephone Station (BTS) 112 there are a plurality of transceiver modules (not shown), as is known in the wireless telephony art, each of which operates at a single channel frequency at a time, and which can handle a predetermined maximum number of telephone calls from wireless telephones 115. In addition, each RASP 113 is assigned to operate at three frequencies to receive signals carrying time division multiplexed wireless telephony signals from a specific group of RADs 114.

Each of RADs 114 a-i has a receive antenna 116 used to receive wireless telephony signals from remote wireless telephones 115, and a transmit antenna 117 used

to transmit wireless telephony signals to wireless telephones 115. For simplicity, the reference numbers 116 and 117 are only shown with the antennas of RAD 114i.

In Figure 2 is shown a general block diagram of one Remote Antenna Driver (RAD) 214. There is a first circuit 218 of RAD 214, that is shown in detail in Figure 3, that carries forward direction telephony signals originating at telephone system 111 and carried via BTS 112, RASP 117, and Broadband Distribution Network 110, to RAD 214 which then processes the signals and re-transmits them via transmit antenna 217 to a wireless telephone 115 (not shown). There is also a second circuit 219 of RAD 214, that is shown in detail in Figure 4, that receives reverse direction wireless telephony signals originating from a wireless telephone 115 via receive antenna 216, processes and encodes the signals, and transmits them via broadband network 110 to RASP 113, and thence via Base Transceiver Station 112 to telephone system 111.

RAD circuits 218 and 219 are connected to and controlled by a microprocessor 220 and logic gate array circuitry. Frequency multiplexed with the wireless telephony signals carried in both directions between RASP 113 and RAD 214 are operational signals of different types that are used for controlling the operation of each RAD 214. These operations include monitoring and reporting circuit operation, gain control, and setting the frequency of operation, of each RAD 214.

In addition, burst signals periodically transmitted to each wireless telephone from BTS 112 are used to synchronize the operation of the RAD 214 with the system as a whole and permit time division multiplexing encoded telephony signals from a plurality of RADs for transmission via Broadband Distribution Network 110 to RASP 113 and BTS 112 in Figure 1. This synchronization is important to the operation of the present invention.

In the prior art GSM wireless telephone system with which the present invention operates, when a particular wireless telephone 115 is not transmitting signals in the reverse direction over network 110 to a RASP 113, the RADs merely do not transmit any reverse path telephony signal. That is, their output amplifiers connected to broadband distribution network 112 have no assigned telephony signals passing through the output amplifier to the network, but they are still connected to the network and the RAD circuitry generates white noise which is placed on network 110. With the large number of RADs connected to Broadband Distribution Network 110 the total amount of "white"

noise introduced onto the network can be relatively large. The non-coherent sum of the noise introduced by the RADs can be expressed by the equation NOISE INCREASE = 10 LOG N, where N is the number of GSM RADs simulcasting over the broadband distribution network toward the RASPs. For example, fifteen RADs will increase the noise in a frequency channel on the broadband distribution network by 12dB. This effectively eliminates at least 75% of the coverage area available from GSM based RADs operating in a non-simulcast mode.

However, with the present invention white noise generated by circuitry in each RAD 114 is effectively decoupled from its output, and the gain level of the RAD circuitry is lowered only during the time slots when wireless telephones are not transmitting telephony signals through the RADs and over the network toward the RASPS for a predetermined short period of time.

As mentioned above, RAD circuits 218 and 219 are connected to and controlled by a microprocessor 220 and logic gate array circuitry and control functions including monitoring and reporting circuit operation, gain control, and setting the frequency of operation, of each RAD 214. The first of the control operations listed is gain control to compensate for losses and gains in RAD 214 and Broadband Distribution Network 110. As one part of this gain control operation RASP 113 sends a frequency multiplexed control signal to RAD 214 that is received by microprocessor 220 on leads CTRL from circuit 218.

RAD 214 also receives an interrogation control signal, as previously described, which cause microprocessor 220 to send back information about RAD circuit 218 (Fig. 3) and circuit 109 (Fig. 4). This information indicates the settings of attenuator pads, the temperature at which each RAD 214 is operating, and the frequency of local oscillators within RAD circuits 218 and 219.

Microprocessor 220 may receive other control signals from RASP 113 and respond thereto to change the frequency of local oscillators within RAD circuits 218 and 219 to thereby change the frequency on which telephony signals and control signals are carried over Broadband Distribution Network 110 between RAD 214 and RASP 113. In this manner the sector or cell which each RAD 114 is assigned may be changed to handle peak traffic loads and for other reasons.

In Figure 3 is shown a detailed block diagram of forward RAD circuit 318 that carries telephony signals originating at telephone system 111 and carried via BTS 112, RASP 113, Broadband Distribution Network 110 and RAD 114 to wireless telephones 115. As previously described, RAD 114 hangs from and is connected to cables of Broadband Distribution Network 110. Transformer 321 is an impedance matching transformer having 75 ohm primary and 50 ohm secondary windings. When Broadband Distribution Network 110 is coaxial cable, the primary winding of transformer 321 terminates a coaxial cable that is split from the main cable in the same manner as a cable drop to a home. Transformer 321 is used to connect frequency multiplexed communications and control signals carried on Broadband Distribution Network 110 from RASPS 113 to the input of all RADs 114..

All RADs 114 assigned to a cell or sector receive control signals directed toward any one of those RADs. However, each RAD 114 has a unique address that is used to identify signals addressed to each RAD 114 by RASP 113.

The frequency multiplexed telephony and control signals received by RAD circuit 318 are input to band pass filter and amplifier 322. This filter passes all frequency multiplexed telephony communication and control signals that are carried in an assigned channel or band on Broadband Distribution Network 110. The amplifier in circuit 322 also amplifies the filtered signals.

The received and amplified telephony and control signals are input to mixer 323 along with a signal from local oscillator 324. The frequency of local oscillator 324 is digitally controlled by microprocessor 220 in Figure 2 responsive to control signals it receives from RASP 113. In a manner well-known in the art, mixer 323 mixes the received signals and the local oscillator 324 signal and outputs many signals which include the communication and control signals meant for this RAD 114. However the frequency of signals of interest are now shifted downward from the carrier frequency used to transmit telephony and control signals to RAD circuit 318. Control signals frequency multiplexed with the telephony signal do not pass through filter 328. Instead, the control signals are input to mixer 345, as is described further in this specification, for further processing and use.

The different frequencies output from mixer 323 are input to band pass filter and amplifier 325 which is tuned to pass and amplify the telephony signals of interest output

from mixer 323 and intended for this RAD 114 and any other RAD that is simulcast. Other frequencies generated in the mixing process are rejected.

RAD circuit 318 handles three channels, all operating at different frequencies, and these three channels are received from Broadband Distribution Network 110. The signals on these three channels are carried together through circuits 321 to 325, but splitter 330 divides the three signals into the separate channels as shown. The circuitry in RAD 318 that handles the three signals is identical so only the circuitry for Channel A is shown and described for simplicity. The signals in Channel A are handled separately up to 3 way combiner 333 where the signals from the three channels (A, B and C) are re-combined for transmission via transmit antenna 317 to wireless telephones 115 (not shown in Figure 3).

The selected set of telephony and control signals are now input to mixer 326. Mixer 326 also has an input from local oscillator 327. Alike other local oscillators in Figure 3, oscillator 327 is digitally controlled by microprocessor 220 responsive to control signals received from RASP 113. In a manner well-known in the art, mixer 326 combines the signals input to it and provides a number of output signals at different frequencies. The different frequencies output from mixer 326 are input to band pass filter and amplifier 328 which passes and amplifies only the telephony signals of interest output from mixer.

The telephony signal of interest is then input to divider 329 which forwards part of the signal to microprocessor 220 as Forward Sample 330 which is described in more detail further in this specification. The forward sample is used in synchronization of the operation of the RASPs 113 and remote RADs 114 to compensate for propagation delays caused by Broadband Distribution Network 110, and thereby permit implement operation of the present invention, as is described further in this specification.

Part of the signal from divider 329 is also input to BTS burst detector 370 which is shown and described in greater detail with reference to Figure 8. Burst detector 370 detects a portion of the signal received from base telephone station (BTS) 112 (shown in Figure 1) to synchronize the operation of the RAD 114 and the wireless telephones 115 with BTS 112 so the wireless telephones send and receive in their proper time slots.

The telephony signal of interest output from amplifier 328 and passing through divider 329 is also input to digitally controlled attenuator 331. Attenuator 331 is used to

adjust the gain level of the signals. Attenuator 331 is part of the gain control system and is digitally controlled by microprocessor 220 responsive to measurements made by microprocessor 220 and signals received from RASP 113. The gain adjusted telephony signal output from attenuator 331 is input to amplifier 332 which amplifies same.

The amplified telephony signal output from amplifier 332 is input to bandpass filter and amplifier 337 to be filtered and amplified before being input to mixer 338. Mixer 338 mixes the telephony signal with the output of local oscillator 339, the frequency of which is controlled by microprocessor 220. The frequency of operation of oscillator 339 is set by a binary word at its control input which is received from microprocessor 220 responsive to a control signal received from RASP 113.

Mixer 338 combines the two signals in a manner well-known in the art to produce several output signals, one of which is the telephony signal having the desired carrier frequency for transmission of the telephony signal via antenna 317 to a remote wireless telephone 115. The signals output from mixer 338 are input to band pass filter 340. Band pass filter 340 passes only the desired carrier frequency. The carrier signal is then filtered again and amplified by bandpass filter and amplifier 341.

The output of bandpass filter and amplifier 341 is input to 3 way combiner which also receives the signal from the identical circuitry in Channels B and C. Combiner 333 combines the three signals at their assigned frequencies and inputs them to detector 342. Detector 342 applies a portion of the signals to bit and power monitor 344, while the remainder of the signals are input to power amplifier 343. Power amplifier 343 amplifies the signals and applies them to transmit antenna 317, and a portion of the signals is also input to bit and power monitor 344. The signals are transmitted within the area of the cell or sector covered by this RAD 114 to be received by specific wireless telephones 115 which are presently operating in that area.

The portion of the telephony signals input to bit and power monitor 344 from detector 342 are sampled to determine the signal level of the telephony signal. An additional input is provided to bit and power monitor 344 from the output of power amplifier 343. These signal levels are reported to microprocessor 220.

Responsive to a control signal received from RASP 113, microprocessor 220 takes this power level information and causes RAD circuit 114 to send this information to RASP 113 as is described with reference to Fig. 4. This information is used by RASP

113 as part of the gain control. In the event that RASP 113 detects a drop in the signal level at bit and power monitor 344, it can send a control signal to microprocessor 220 to adjust the gain in the three channels of RAD circuit 318 by re-setting attenuator 331. If there is no transmit signal, or if the transmit signal is too high to be compensated for with attenuator 331, RASP 113 will send a control signal which will cause microprocessor 220 to take this RAD 114 off line until the problem is fixed.

When RAD 114 circuit 318 receives control signals directed to it by RASP 113, as indicated by a unique address for each RAD, microprocessor 220 of the addressed RAD responds thereto to perform the requested action. These actions may be requests for information about the operation of RAD 114, to make changes to circuit settings in RAD 114, or to place the RAD on or off line.

The control signal may ask for the settings of the local oscillators and attenuators. The control signal from RASP 113 may also indicate revised settings for local oscillators and attenuators. Microprocessor 220 makes the required changes and then sends a confirmation signal back to RASP 113 indicating that the requested changes have been made. As part of the gain control operation the control signal from RASP 113 will also request information concerning the output levels, or lack thereof, from bit and power monitors 344 and 474. Microprocessor 220 also returns this information to RASP 113.

Reference channel oscillator 347 uses the output of mixer 345, which includes a reference signal from RASP 113, as a reference oscillator to generate a phase lock loop reference signal that is used to provide a master frequency to all local oscillators within all RAD 114s to match their frequency of operation with RASP 113.

In Figure 4 is shown a detailed block diagram of reverse RAD circuit 419 within RAD 114. RAD circuit 419 carries telephony signals from wireless telephones 115, via Broadband Communications Network 110, RASP 113 and Base Telephone Station 112 to Telephone System 111.

Telephony signals from wireless telephones 115 (not shown) and received by receive antenna 218 are input to an amplifier 449. The amplified signal is then input to filter 450 which removes extraneous signals. The filtered signals are then amplified and re-filtered by amplifier and band pass filter 451.

RAD circuit 419 also handles three channels, all operating at different frequencies. Each of these channels handles communications with several wireless

telephone 115. The multiple signals on these three channels are carried together through input circuits 449, 450 and 451, and splitter 452 divides the signals into the three separate channels as shown. The circuitry in RAD 419 that handles signals in each channel is identical so only the circuitry for Channel A is shown and described for simplicity. The multiple signals in Channel A are handled separately up to combiner 469 where the signals from the three channels (A, B and C) are re-combined (frequency multiplexed) for transmission via broadband distribution network 110 to a RASP 113 and BTS 112 (the latter are shown in Figure 1).

The telephony signal (modulated RF carrier) received from remote wireless telephone 114, is then input to splitter 452 which provides three identical outputs. Only the RAD circuitry for one channel is shown. The signals for the other two channels go to identical circuitry via leads CHANNEL B and CHANNEL C, which are not shown.

The amplified and filtered signals for Channel A are then amplified by amplifier 453 before being input to mixer 454. Mixer 454 has a second input from local oscillator 327, and the signals are mixed in a manner well known in the art to produce a number of output signals.

The frequency of local oscillator 455 is digitally controlled and is determined by a binary word applied to its control input. A control signal sent from RASP 113 to microprocessor 220 causes the microprocessor to send the proper binary words to the control input of local oscillator 455 to set the frequency of local oscillator 454. Similarly, microprocessor 220 sets the frequency of digitally controlled local oscillator 466 and control signal oscillator 471 depending on the received carrier frequency chosen.

The operation of mixer 454 results in multiple frequencies being output from the mixer as is known in the art. All these signals are input to bandpass filter and amplifier 456 which selects only the difference frequency carrier modulated by the telephony signal created by mixer 454 and amplifies same.

The frequency shifted carrier modulated by the telephony signal is then input to SAW filter 457 which is a very narrow band filter that removes even more extraneous signals from the desired signal. The filtered signal is then amplified by amplifier 459 and is input to divider 459 which applies the signal to both SAW filter 460 and amplifier 475 while isolating the two circuits from each other.

The amplified signal output from amplifier 475 is put through a logarithmic detector 476 to compress the range of the analog signal. The signal is then applied to analog to digital converter 477, which is shown in more detail in Figure 9, to digitize the signal. The digitized signal is then input to gate array circuit 478 where it is used to set the gain level of RAD circuitry 419 by controlling attenuator 462 and, in accordance with the teaching of the present invention, to control the operation of switch 483 and attenuator 462 to implement the time slot muting.

SAW filter 460 is used to filter the received signals even further, and then the signals are amplified by amplifier 461.

The amplified signals are then input to attenuator 462 which is used to adjust the gain level of the signal. The amount of attenuation provided by step attenuator 462 is controlled by a binary word at its control input from gate array logic 478. The gate array 478 provides an output that is dependent on the strength of the received wireless telephone signal.

Attenuator 462 is also used to implement time slot muting in accordance with the teaching of the present invention. As described above, after a predetermined period (often one-hundred twenty-eight time consecutive slots) time slot muting is implemented when there is a prolonged absence of communication signals from a wireless telephone 115 in a given time slot. As part of the time slot muting, the gate array causes the attenuation of digitally controlled attenuator 462 to increase to its maximum value after the absence of communications signals received from a wireless telephone 115 for the predetermined period. As mentioned above the absence of signals in each time slot is detected by log detector 476. The overall result is that the series noise gain in CHANNEL A of RAD circuit 419 is significantly below the noise level of broadband distribution network 110.

The telephony signal output from step attenuator 462 is then amplified by amplifier 464 before being input to mixer 465 along with a signal from local oscillator 466. The frequency of local oscillator 466 is determined by a binary word applied to its control input from microprocessor 220. As previously described, microprocessor 220 sets the frequency of operation of the local oscillators as indicated by control signals received from RASP 113 to set the frequency of operation of this RAD 114 on Broadband Distribution Network 110.

The signals output from mixer 465 are now at the frequency that will be transmitted via Broadband Distribution Network 110. They are input to bandpass filter and amplifier 467 which filters out the unwanted signals from the mixing / heterodyning process and amplifies the selected signals which are then input to combiner 468.

When there is no signal from a wireless telephone 115 for a predetermined period, as described further in this specification, the microprocessor working in conjunction with gate array 478, operates transistor switch 483 to disconnect local oscillator 466 from mixer 465. As a result no mixing action takes place to produce a signal that will pass through bandpass filter and amplifier 467 to signal combiner 468. This, combined with increasing attenuator 462 to its maximum, effectively isolates any noise received via antenna 218 and the front end of RAD circuit 419 from being combined with signals and / or noise in CHANNELS B and C. As described above, since communication signals from a maximum of eight wireless telephones may be carried in each of CHANNELS A, B and C in different time slots (which are described further in this detailed description), when there is no communication signal in a time slot for a predetermined period of time (defined as a number of time slots), switch 483 is operated only during each periodic occurrence of that time slot to create the "time slot muting" of the present invention. The time slot muting minimizes reverse path noise during the time slots in which there is no signals for the predetermined period of time. A total of one-hundred twenty-eight time slots is often used for the predetermined period of time. This takes into account that there may be temporary disruptions of communications signals received from a wireless telephone 115 caused by many factors, including buildings, and muting is not implemented and / or the call will not inadvertently be terminated. As is described hereinafter with reference to Figure 9, the absence of signals in each time slot is detected by log detector 476. In a similar manner, when the received signal level on a muted time slot exceeds a preset level, that time slot will unmute and remain unmuted until no signal is detected for the previously described "predetermined period of time".

The overall result of the time slot muting implemented as described herein is that the series noise gain in CHANNEL A of RAD circuit 419 is significantly below the noise level of broadband distribution network 110.

As described above with reference to splitter 452, there can be a maximum of three signals being received by antenna 218 at any moment in time, one from each of the three channels A, B and C handled by this RAD 114. The signals from each of these three channels are at different frequencies and are separated by splitter 452 for individually handling. After the three signals are handled as described above for Channel A, they are recombined by combiner 468. In addition, each of the three signals can have multiplexed thereon, in time division multiplexing format, the signals of a maximum of eight wireless telephones. Thus, a maximum of twenty-four telephone calls can be handled by each RAD 114. This is described in further detail with reference to the time slots shown in Figure 5.

The three re-combined signals output from combiner 468 are filtered and amplified by bandpass filter and amplifier 472 before being transmitted via Broadband Distribution Network 110 to a RASP 113.

Transformer coupler 473 receives from bandpass filter and amplifier 472 the signals to be transmitted to a RASP 113. Transformer 473 is an impedance matching transformer having 50 ohm primary and 75 ohm secondary windings. When Broadband Distribution Network 110 is coaxial cable, the primary winding of transformer 473 terminates a coaxial cable that is split from the main cable in the same manner as a cable drop to a home. As previously described, RADs 114 a-i hang from the coaxial cabling of Broadband Distribution Network 110. In other applications, such as with fiber optic cable, other well known frequency conversion and signal coupling techniques are used.

Responsive to some control signals received from RASP 113, microprocessor 220 sends information signals back to RASP 113. Microprocessor 220 does this by keying control signal oscillator 471 to produce an information signal. The information signal indicates various information about the three aforementioned channels in this RAD 114, but particularly including the settings of step attenuators and measurements made by bit and power monitors 344 and 474. RASP 113 uses this information to keep an updated status regarding each of the RADs 114 a-i.

A small portion of the frequency multiplexed signals passing through transformer coupler 473 is coupled to Built In Test (BIT) and power monitor 474. Power monitor 474 samples the signal level of the combined signal that is being input to Broadband

Distribution Network 110 and reports this information to RASP 113 using control signal oscillator 471 as previously described.

In Figure 5 is shown a two frame representation of the continuous time frames of a GSM wireless telephony system utilized with a wireless telephone system of the type described in this specification. In addition to the frequency multiplexing described above for the three channels handled by a RAD 114, each RAD in a GSM wireless telephony system utilizes a time division multiplexing arrangement for the eight wireless telephone signals in each channel wherein, at given assigned frequencies for forward and reverse communications, there is a continuous sequence of time frames each made up of a eight time slots, as shown. In Figure 5 two representative time frames are shown, and each time frame has eight time slots designated t0 to t7. Along a communication path, such as Broadband Distribution Network 114, a maximum of eight mobile telephones are assigned time slots within a time frame on a pair of frequencies (transmit and receive). Thus, a RAD 114 can handle a maximum of twenty-one wireless telephone calls at a time, seven for each of the three channels A, B and C handled by the RAD.

In operation of a GSM system, BTS 112 transmits a burst tone in a time slot of each time frame, as shown for each mobile user on a channel. This burst tone is detected by a level detector in each RAD 114, which resets the timing therein for determining the beginning of each time slot in each frame. In response to each received burst tone output from the level detector (not shown in Fig. 5), gate array 478 creates a pulse train that defines the beginning of the time slots. This technique enables the RAD 114 to adjust its internal timing to compensate for propagation delays that exist between BTS 112 and RAD 114.

In prior art GSM systems functioning with a wireless telephony system of the type described herein, the reverse RAD circuitry 419 in each of RADs a-i transmits continuously. The presence of telephony signals on the RAD 114 days known only to Base Telephone Station (BTS) 112. However, when a wireless telephone 115 is not using the RAD 114 to communicate to BTS 112, RAD 114 is still transmitting the received spectrum over Broadband Distribution Network 110 to a RASP 113. This spectrum, in the absence of a signal from a wireless telephone, is white noise. This white noise is placed on Broadband Distribution Network 110. With the many RADs connected to Broadband Distribution Network 110 the total amount of white noise is

appreciable. For example, fifteen RADs 114 connected to Broadband Distribution Network 110 will increase the noise in a frequency channel on the network by 12dB. This has the effect of dramatically reducing the effective range of each RAD 114.

In accordance with the teaching of the present invention, during any time slot when a RAD 114 is not being used by a wireless telephone to transmit telephony signals over Broadband Distribution Network 110 to a RASP 113, energy and noise are not applied to Broadband Distribution Network 110. This may be called time slot muting. In this manner there is a significant reduction in the level of white noise introduced onto the reverse path of Broadband Distribution Network 110.

To implement the present invention there must be a correction made for the propagation delay of communication signals transmitted over Broadband Distribution Network 110 between each RAD 114 and BTS 112. The forward and reverse link propagation delay timing offset is established at BTS 112 in accordance with standard GSM protocols. A nonvolatile memory in each RAD 114 is used to store the time offset associated with each RAD 114. Once the precise time offset is known and stored, no change in settings is required unless the signal path from BTS 112 and a RAD 114 is changed.

In accordance with standard GSM protocols, the timing offset is adjusted, at the wireless telephone 115 such that the received and transmit burst tone pair from an individual wireless telephone is three time slots apart at BTS 112. The reverse propagation delay plus the forward propagation delay is added to the timing offset of a wireless telephone handset. The Broadband Distribution Network 110 is part of this total propagation delay. This additional delay causes the reverse link time slots to arrive at a RAD 114 proportionately delayed.

In Figure 6 is shown an example of propagation delay. The top of the figure shows the timing relationship between transmitted and received signals at BTS 112. The lower half of the figure shows the timing relationship at a RAD 114 when it is connected to BTS 112 through a wideband distribution network cable which introduces 50 microseconds of delay. It is necessary to know the offset from BTS 112 in order to establish the precise timing of my novel time slot mute function.

Figure 7 shows how in each time slot samples of the received signal are taken every 100 microseconds in a manner well known in the art.

In Figure 8 is shown a block diagram of a BTS burst detector 370, which is an expansion of this circuit shown as a single block 370 in Figure 3. This detector utilizes a logarithmic detector comprising level detector 875 and low pass filter 876 and is set for a 500kHz bandwidth. This wideband log detector, functioning with the high signal-to-noise ratio present on the forward path, provides an accurate measure of the beginning of the first time slot in each time frame. The output of comparator 877 is fed to gate array circuit 478 which is logic that controls all the circuitry in the RAD. The output of comparator 877 is a timing reset pulse utilized by gate array circuit 478 to generate timing pulses that carefully define each time slot in each time frame to synchronize the operation of wireless telephones 115 communicating with a RAD 114, RASP 113 and BTS 112.

The output of the logarithmic level detector is input to comparator 877 along with a dc voltage from threshold dc level circuit 878. When the forward power into the logarithmic detector, from a burst tone, causes a voltage that exceeds the threshold voltage from circuit 878, comparator 877 toggles high, indicating the rising edge of time slot t0. In this embodiment of the invention it is not necessary to precisely set the threshold voltage. It is only necessary to set the level high enough to avoid noise triggering.

In Figure 9 is shown a block diagram of log detector 476 which is shown as a single block in Figure 4. There are three of the circuits, one for each of the three channels A, B and C inside a RAD circuit 419 (although only one is shown in Figures 4 and 9). The analog signal from amplifier 475 in Figure 4 is input to logarithmic level detector 979 which amplifies the signal and inputs it to filters 980 and 981 which are connected in cascade. Switch 982 is connected to the output of both filters as shown, and the switch is controlled such that it can selectively insert or remove slow response, low pass filter 981. Filter 980 has a fast response. Samples taken with only the fast response filter are used to prevent the RAD from overloading Broadband Distribution Network 110. Filter 981 as a slow response (narrow bandwidth) and is used to measure the relative signal level received from a wireless telephone / mobile user 115 The narrow bandwidth provides improved sensitivity necessary to measure low-level signals.

The signal output from switch 982 is input to A / D converter 477, and thence to gate array circuit 478 in Figure 4 where it is used to set the gain level of RAD circuitry

419 by controlling attenuator 462. The signal received from the wireless telephone 115 is sampled four times within the assigned transmission time slot to determine its power level. The sampling is shown in Figure 8. These four samples are spaced 100 microseconds apart and start approximately 88.5 microseconds from the beginning of the time slot. The four samples are averaged to form a signal power level determination for the wireless telephone signal in each of the three channels. More importantly, in accordance with the teaching of the present invention, log detector 476 is used to sense the presence or absence of communication signals in each time slot. When there is no signal present over the aforementioned one-hundred twenty-eight time slots of the predetermined period of time, this is sensed and switches 483 and attenuator 462 are operated to implement the time slot muting.

While what has been described hereinabove is the preferred embodiment of the dynamic re-allocation of the RADs, it can be understood that numerous changes may be made by those skilled in the art without departing from the scope of the invention. For example, while what has been described is used in a GSM system, the invention may also be used in other time division multiple access wireless telephone systems wherein the RADs normally have their outputs connected to broadband distribution network and contribute to the white noise thereon when no signals are being transmitted by a RAD over the network to a central RASP.

What is claimed is:

1. In a GSM wireless telephony system, apparatus for reducing noise on the reverse link over which communication signals are sent from a plurality of wireless telephones to a plurality of remotely located transceivers, then over a connection path to centrally located transceivers and on to central telephone station equipment; wherein said GSM system utilizes a discrete time slot of a plurality of repeating time slots to carry communications signals between each wireless telephone and the centrally located transceivers, wherein the improvement comprises:

means in each of said remotely located transceivers responsive to the lack of receipt of a communications signal from a wireless telephone for changing the operation of said remotely located transceivers to reduce noise output from said transceivers onto said connection path, said change in operation occurring only during one of said time slots in which said last mentioned wireless telephone is sending communications signals to said remotely located transceivers.

2. The invention in accordance with claim 1 wherein said means for changing the operation of said remotely located transceivers comprises:

means for detecting the presence or absence of a received communications signal from a wireless telephone.

3. The invention in accordance with claim 2 wherein said means for changing the operation of said remotely located transceivers further comprises:

logic means responsive to said detecting means for determining if the communications signal received from a wireless telephone in a discrete time slot of said plurality of repeating time slots is absent in a predetermined number of said last mentioned discrete time slots which are being used to carry said last mentioned

communications signal, said logic means causing said changes in said remotely located transceivers to reduce noise output from said transceivers onto said connection path.

4. The invention in accordance with claim 3 wherein said means for changing the operation of said remotely located transceivers further comprises:

switch means responsive to said logic means determining that said communications signal is not being received from a wireless telephone in a discrete time slot of said plurality of repeating time slots for changing the operation of predetermined circuits within said remotely located transceiver to reduce noise output from said transceivers onto said connection path.

5. The invention in accordance with claim 4 wherein said means for changing the operation of said remotely located transceivers further comprises:

means responsive to said logic means determining that said communications signal is not being received from a wireless telephone in a discrete time slot of said plurality of repeating time slots for increasing the insertion loss of an attenuator in said remotely located transceiver to reduce noise output from said transceivers onto said connection path.

6. The invention in accordance with claim 3 wherein said means for changing the operation of said remotely located transceivers further comprises:

means responsive to said logic means determining that said communications signal is not being received from a wireless telephone in a discrete time slot of said plurality of repeating time slots for increasing the insertion loss of an attenuator in said remotely located transceiver to reduce noise output from said transceivers onto said connection path.

7. A method for reducing noise on the reverse link of a wireless telephony system over which communication signals are sent from a plurality of wireless telephones to ones of a plurality of remotely located transceivers, then over a connection path to centrally located transceivers and on to central telephone station equipment; wherein said wireless telephony system utilizes a discrete time slot of a plurality of repeating time slots to carry communications signals between each wireless telephone and the centrally located transceivers, said method comprising the steps of:

detecting the presence or absence of a received communications signal from one of said wireless telephones that is operating with one of said remotely located transceivers;

determining if the communications signal received from said last mentioned wireless telephone is absent in a predetermined number of said one of said discrete time slots which are being used to carry said last mentioned communications signal; and

changing the operation of said one of said remotely located transceivers to reduce noise output therefrom onto said connection path if it has been determined that said last mentioned communication signal is absent in a predetermined number of said one of said discrete time slots, said change in operation occurring only during said one of said time slots in which said one of said wireless telephones is normally sending its communications signal to said one of said remotely located transceivers.

8. The method in accordance with claim 7 wherein the step of changing the operation of said one of said remotely located transceivers to reduce noise output therefrom onto said connection path further comprises the step of:

changing the operation of predetermined circuits within said one of said remotely located transceivers to reduce noise output therefrom onto said connection path when it has been determined that said last mentioned communications signal is absent in

a predetermined number of said one of said discrete time slots, said change in operation of said predetermined circuits occurring only during said one of said discrete time slots in which said one of said wireless telephones is normally sending its communications signals to said one of said remotely located transceivers.

9. The method in accordance with claim 8 wherein the step of changing the operation of said one of said remotely located transceivers to reduce noise output therefrom onto said connection path further comprises the step of:

increasing the insertion loss of an attenuator in said one of said remotely located transceivers to reduce noise output therefrom onto said connection path when it has been determined that said last mentioned communications signal is absent in a predetermined number of said one of said discrete time slots, said increase of impedance occurring only during said one of said discrete time slots in which said one of said wireless telephones is normally sending its communications signals to said one of said remotely located transceivers.

10. The method in accordance with claim 9 wherein said method further comprises the step of:

restoring the operation of said one of said remotely located transceivers to normal if it has been determined that said last mentioned communication signal is again present in any of said one of said discrete time slots, said restoration of operation occurring only during said one of said time slots in which said one of said wireless telephones is normally sending its communications signal to said one of said remotely located transceivers.

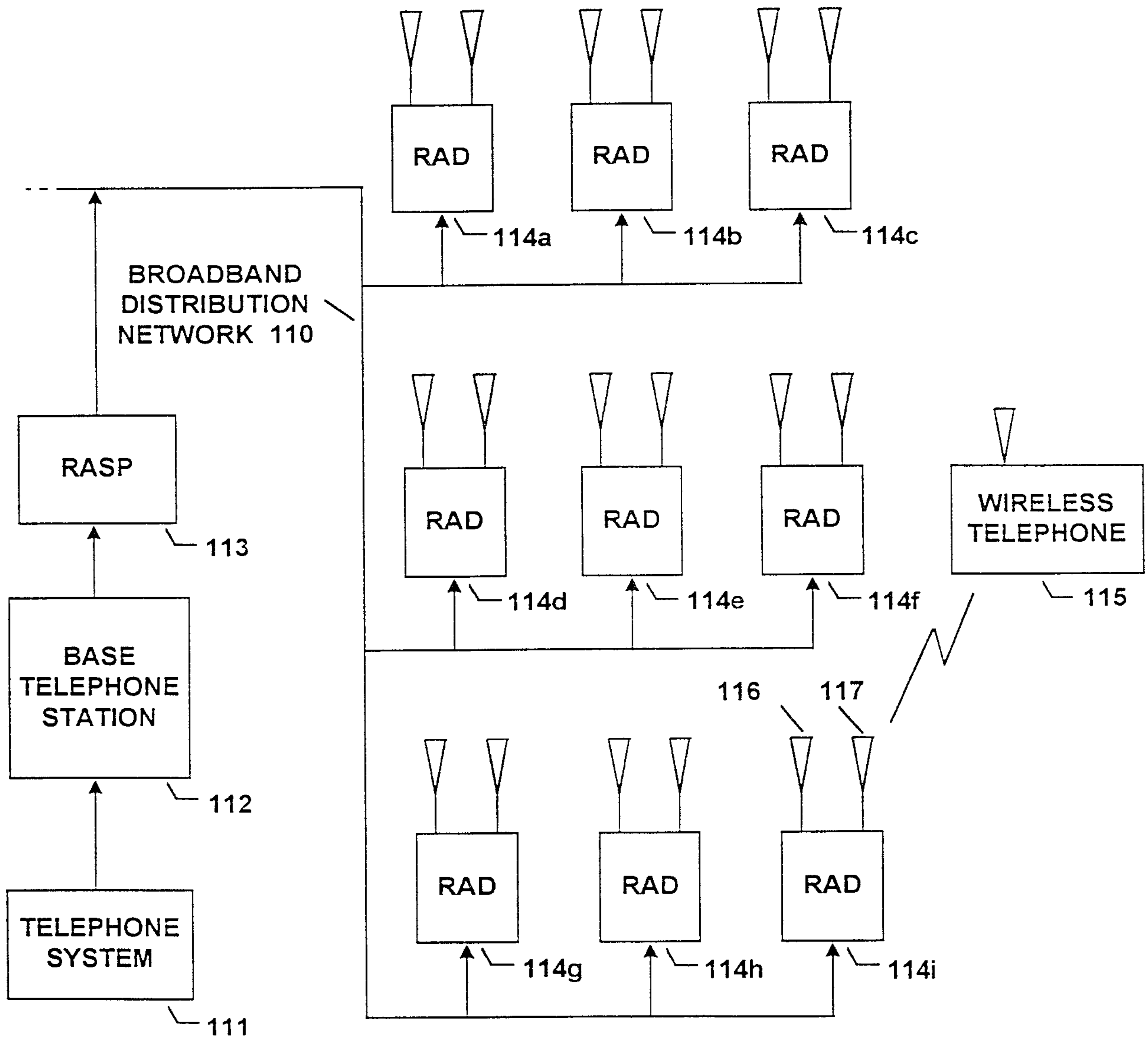

RAD
RAD
RAD
114a
114b
114c
BROADBAND
DISTRIBUTION
NETWORK 110
RASP
113
RAD
RAD
RAD
WIRELESS
TELEPHONE
114d
114e
114f
115
BASE
TELEPHONE
STATION
116
117
112
RAD
RAD
RAD
TELEPHONE
SYSTEM
114g
114h
114i
111

FIGURE 1

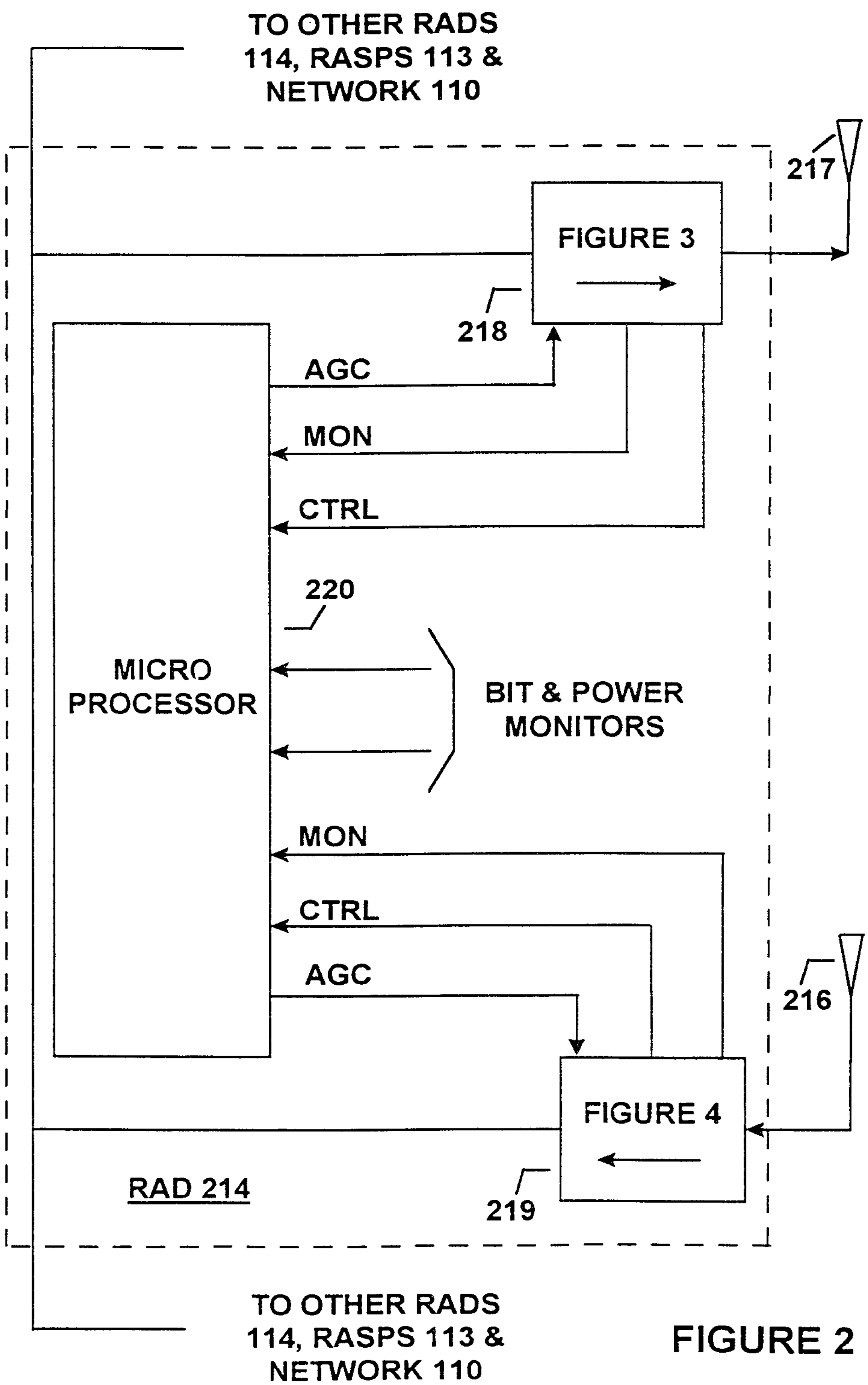

TO OTHER RADS
114, RASPS 113 &
NETWORK 110
217
FIGURE 3
218
AGC
MON
CTRL
220
MICRO
PROCESSOR
BIT & POWER
MONITORS
MON
CTRL
AGC
216
FIGURE 4
RAD 214
219
TO OTHER RADS
114, RASPS 113 &
NETWORK 110

FIGURE 2

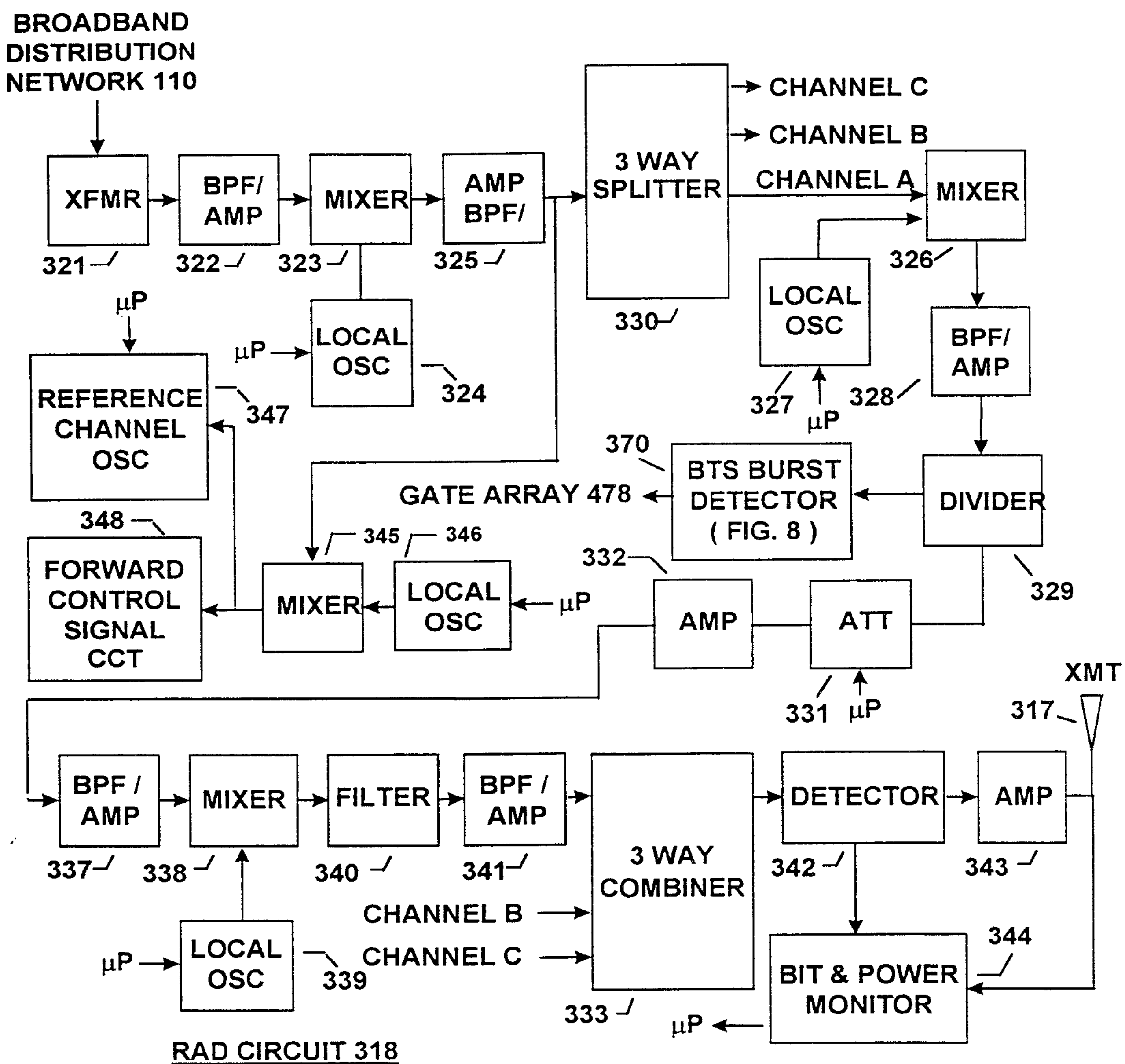
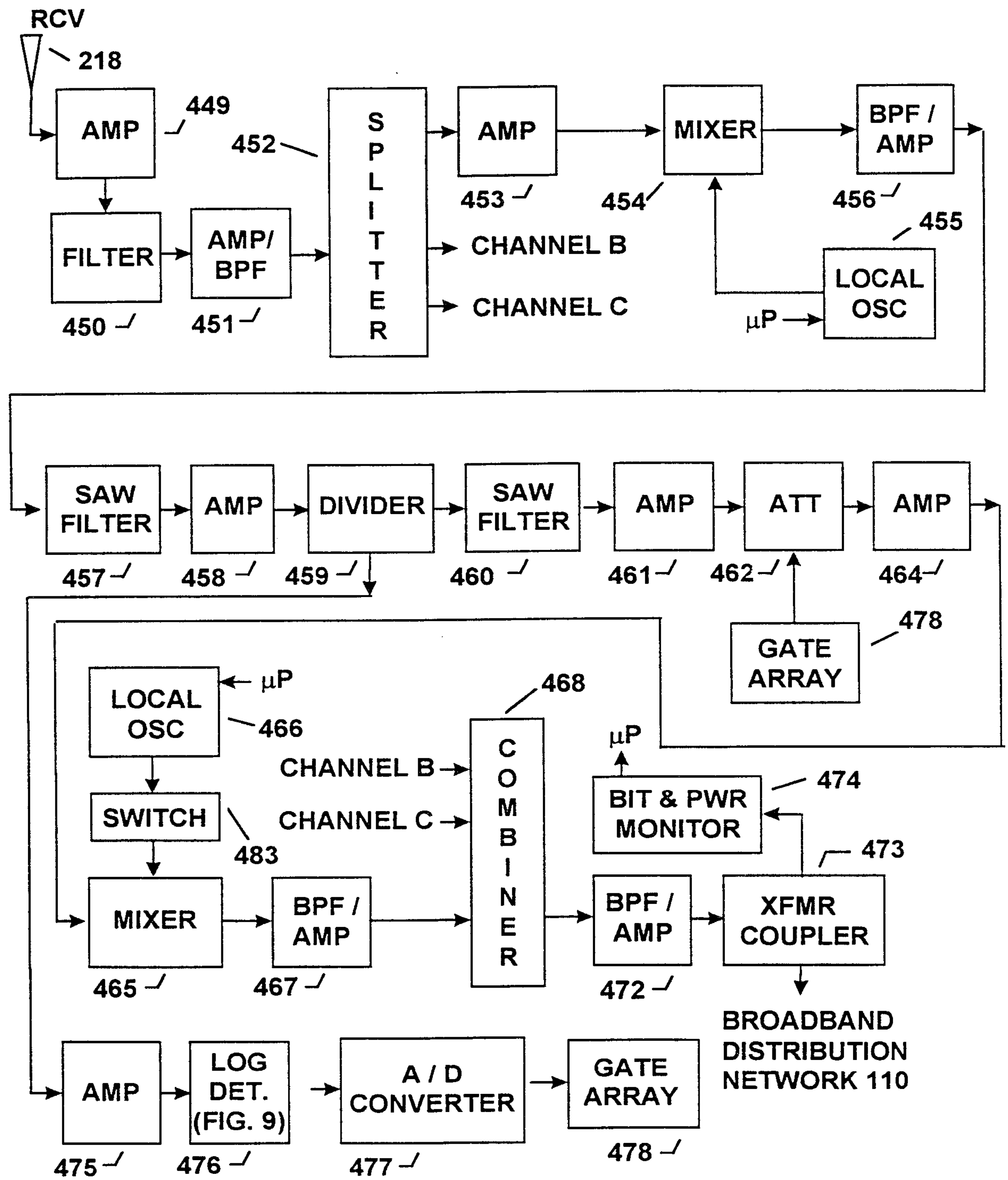

BROADBAND DISTRIBUTION NETWORK 110
XFMR
BPF/ AMP
MIXER
AMP BPF/
3 WAY SPLITTER
CHANNEL C
CHANNEL B
CHANNEL A
MIXER
321
322
323
325
330
326
LOCAL OSC
BPF/ AMP
327
328
μP
REFERENCE CHANNEL OSC
LOCAL OSC
324
347
370
BTS BURST DETECTOR (FIG. 8)
DIVIDER
GATE ARRAY 478
348
FORWARD CONTROL SIGNAL CCT
MIXER
LOCAL OSC
345
346
332
329
AMP
ATT
331
XMT
317
BPF / AMP
MIXER
FILTER
BPF / AMP
3 WAY COMBINER
DETECTOR
AMP
337
338
340
341
342
343
344
BIT & POWER MONITOR
339
333
RAD CIRCUIT 318

FIGURE 3



RAD CIRCUIT 419

FIGURE 4

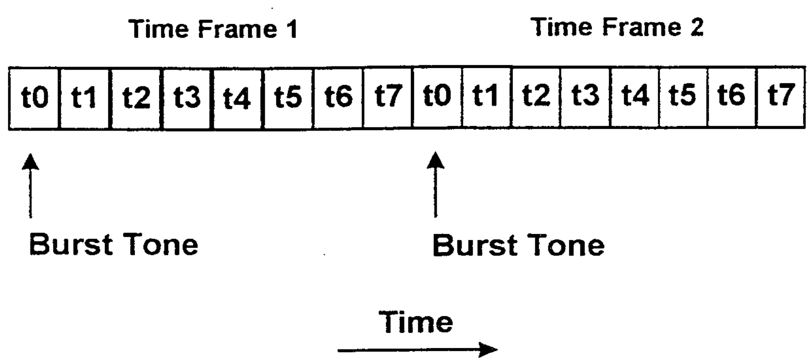


FIGURE 5

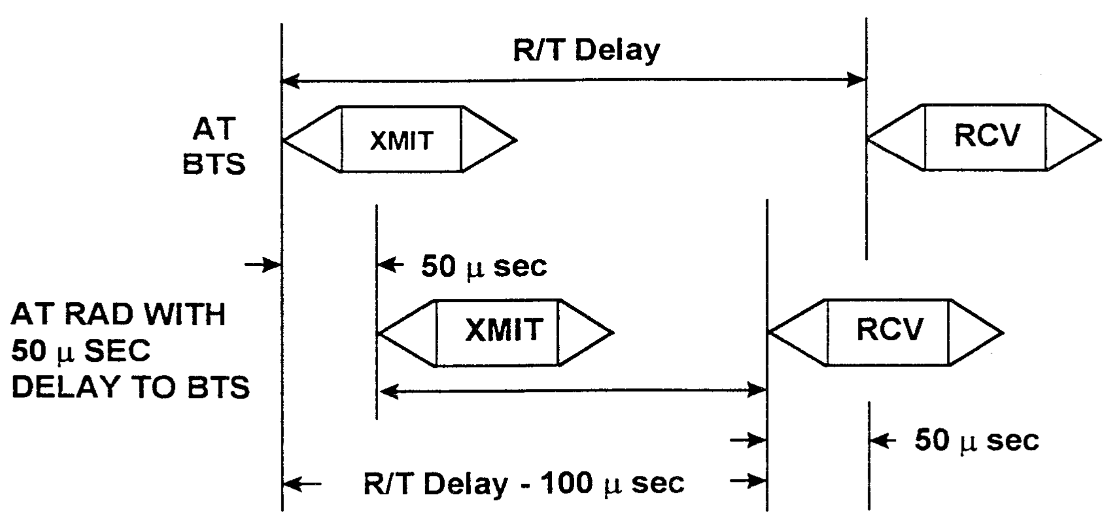


FIGURE 6

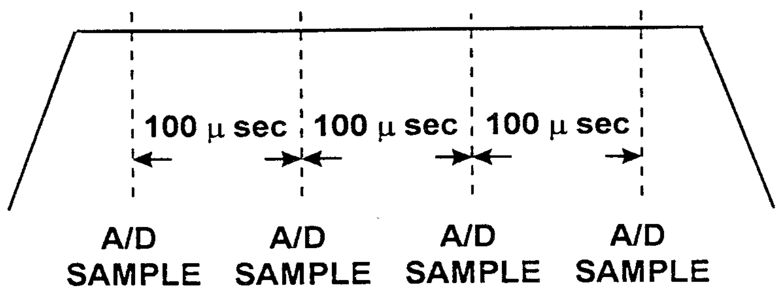

100 μ sec
100 μ sec
100 μ sec
A/D SAMPLE
A/D SAMPLE
A/D SAMPLE
A/D SAMPLE

FIGURE 7

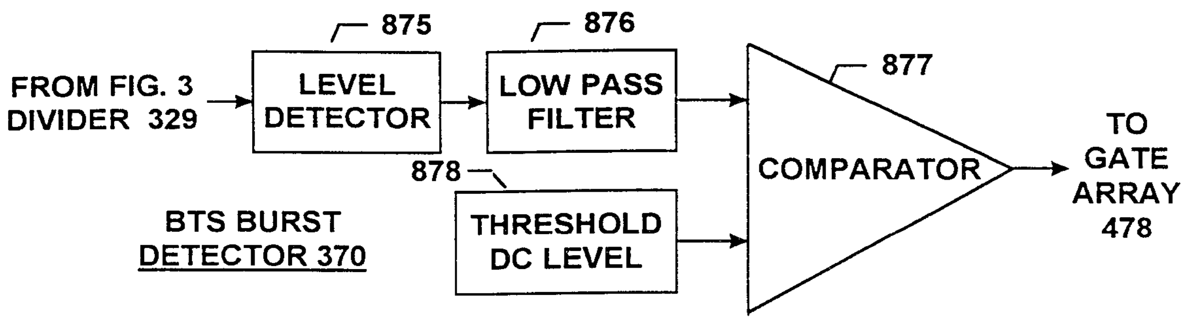


FIGURE 8

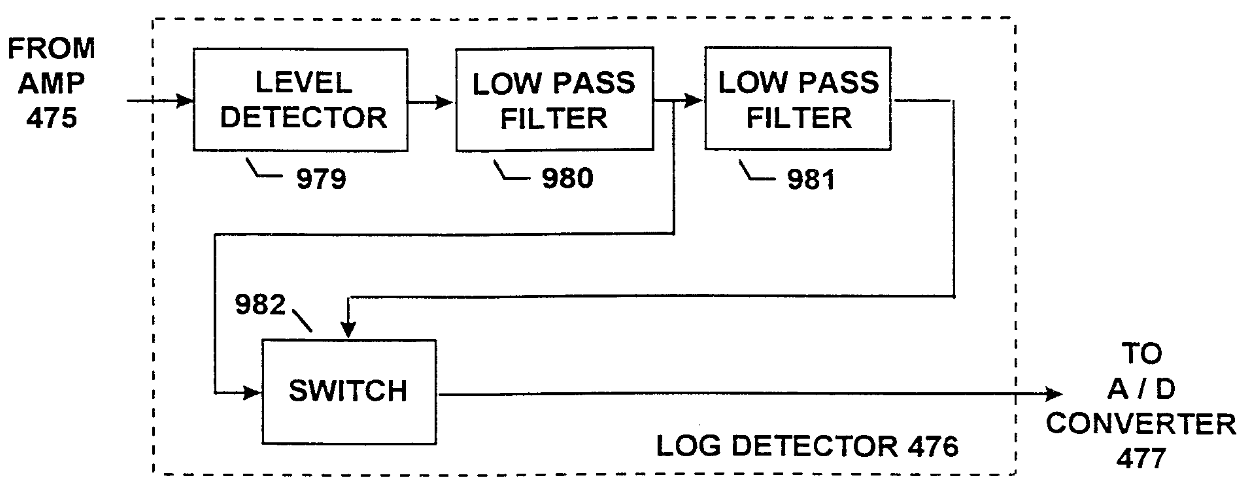


FIGURE 9

INTERNATIONAL SEARCH REPORT

International Application No
PC.,/US 99/13596

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/30 H03G3/34 H04B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04B H03G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 678 177 A (BEASLEY ANDREW) 14 October 1997 (1997-10-14) column 1, line 60 -column 2, line 14 column 3, line 38 - line 45 column 6, line 22 - line 49 column 7, line 25 - line 53	1-10
A	GB 2 166 325 A (PHILIPS ELECTRONIC ASSOCIATED) 30 April 1986 (1986-04-30) page 1, right-hand column, line 91 - line 127	1-10
A	PATENT ABSTRACTS OF JAPAN vol. 009, no. 065 (E-304), 26 March 1985 (1985-03-26) & JP 59 204330 A (MATSUSHITA DENKI SANGYO KK), 19 November 1984 (1984-11-19) abstract	1-10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 1999	01/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Larcinese, A

1

INTERNATIONAL SEARCH REPORT

International Application No
PC US 99/13596

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5678177 A	14-10-1997	AU 4554993 A	31-01-1994
		DE 69305530 D	21-11-1996
		DE 69305530 T	22-05-1997
		EP 0664940 A	02-08-1995
GB 2166325 A	30-04-1986	NONE	
JP 59204330 A	19-11-1984	NONE	